INDOOR AIR QUALITY REASSESSMENT

Undermountain Elementary School
491 Berkshire School Road
Sheffield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

July, 2002

Background/Introduction

At the request of Frederick Finkle, Director of Buildings and Grounds for the Southern Berkshire Regional School District, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), conducted a reassessment of the Undermountain Elementary School, 491 Berkshire School Road, Sheffield, Massachusetts. The school was previously visited on November 2, 2000 by BEHA's ER/IAQ program. A report was issued (MDPH, 2001) which described the conditions of the building at that time. The report identified problems and made recommendations to improve indoor air quality in various sections of the school. A summary of actions taken on previous recommendations is included as Appendix I of this report. On April 3, 2002, Mike Feeney, Director of the ER/IAQ Program, returned to the school to do the reassessment.

The Undermountain Elementary School is part of a larger school complex that includes the Mount Everett School. This report describes the conditions noted within the Undermountain Elementary School only. The indoor air quality assessment of the Mount Everett School will be subject of a separate report.

The original building was constructed in 1955 as a single-story, red brick structure. A wing was added in 1966. The building underwent renovations in 1993. These renovations installed hallways along original exterior classroom walls, resulting in the enclosure of windows indoors. The enclosed classrooms (e.g., the music room) are dependent on mechanical ventilation for air exchange. The remainder of classrooms have openable windows. The school contains general classrooms, main administrative office, library, cafeteria, gymnasium, art room, and music room. The building is covered by a peaked roof.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 380 and a staff of approximately 50. Tests were taken during normal operations at the school and results appear in the Tables 1-8.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in eleven of thirty-two areas (~34%) surveyed, which indicates a ventilation problem in some sections of the school. These measurements are an improvement compared to carbon dioxide sampling conducted on November 2, 2000, when twenty-three of thirty-four areas (~68%) surveyed had carbon dioxide levels above 800 ppm. A comparison of test results is included in Tables 4-8. It is also important to note that some classrooms had open windows during the reassessment, which can greatly contribute to reduced carbon dioxide levels. Also of note was the computer room, which had a carbon dioxide level of over 2,000 ppm, indicating little to no air exchange. While the function of the ventilation system has improved, further adjustment appears warranted.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents were operating in all but one classroom (see Tables).

Exhaust ventilation in classrooms is provided by a mechanical exhaust system. The exhaust vents are located along interior hallway walls of classrooms. In some cases, classroom exhaust vents located above wall-mounted cabinets can become prone to blockage by stored materials. No blockages of exhaust vents were observed.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult Appendix II.

Temperature readings recorded during the assessment ranged from 69 ^{o}F to 75 ^{o}F, which were mostly within the BEHA's recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o}F to 78 ^{o}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 35 to 45 percent, which were within or close to BEHA comfort guidelines. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Several rooms contained a number of plants, some of which were located near univents. Plant soil and drip pans can provide sources of mold growth. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents to prevent the aerosolization of mold, dirt and pollen.

Of note was the absence of a gutter/downspout system along the peaked roof to direct rainwater from the base of exterior walls. After rainstorms, the exterior walls are saturated with moisture along some areas of the building (see Picture 1). Rainwater runs off the roof onto the ground at the base of the building. In one section equipped with a gutter/downspout system, rainwater was pouring from the gutter onto concrete (see Picture 2). Excessive water exposure to exterior brickwork can result in damage over time. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. Accumulated chalk dust was noted in several classrooms. Chalk dust is a fine particulate, which can be easily aerosolized and serve as an eye and respiratory irritant. Also of note was the amount of materials stored inside some classrooms. In classrooms throughout the school, items were seen piled on windowsills, tabletops, counters, bookcases and desks. The large amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. Items should be relocated and/or cleaned periodically to avoid excessive dust build up. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Univents were spot checked throughout the school complex. In some cases, the univent filter was removed from the univent and found to be smaller than the filter rack (see Picture 3).

Filters should be of sufficient size to fit flush into the entire filter rack. If filters do not fit flush with filter racks, air drawn into the univent will bypass filters and pass through spaces between filters and racks. This can result in dust, dirt and other debris being distributed by the ventilation system.

A number of classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, M.A., 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis or every six months if dusty conditions exist outdoors (IICR, 2000).

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (see Picture 4). Tennis balls are made of a number of materials that are sources of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gassing volatile organic compounds (VOCs). Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix III (NIOSH, 1998).

Student art projects constructed of food boxes were stored in classrooms. Food and their containers may have residue that can serve to attract pests (e.g., mice and cockroaches). The use of these types of materials should be avoided to reduce the need for pesticide application to rid the building of infestations.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Continue to examine univents throughout the school for function. Survey classrooms for air diffuser and exhaust vent function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Continue to ensure that ground level fresh air intakes remain clear of blockages, particularly snow in winter. Avoid grass cutting during school hours.
3. Consider increasing the dust spot efficiency of filters to increase the removal of particulates from the environment. Ensure filters fit properly into their filter racks.
4. Continue to examine ventilation system balancing.
5. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning practices to minimize common indoor air contaminants, whose irritant effects can be enhanced when the relative humidity is low, should be implemented. Among these methods can be the use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance filter (HEPA). Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
6. Remove plants from univent air stream. Ensure plants have drip pans. Examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary.

7. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
8. Discontinue the use of tennis balls on chairs to prevent generation of latex dust.
9. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
10. Clean chalk boards and chalk trays regularly to avoid the excessive build-up of chalk dust.
11. Consider installing a gutter/downspout system on the edge of the peaked roofs of the building to direct water away from the base of the building. The installation of a drainage system may also be necessary to direct water away from the foundation.

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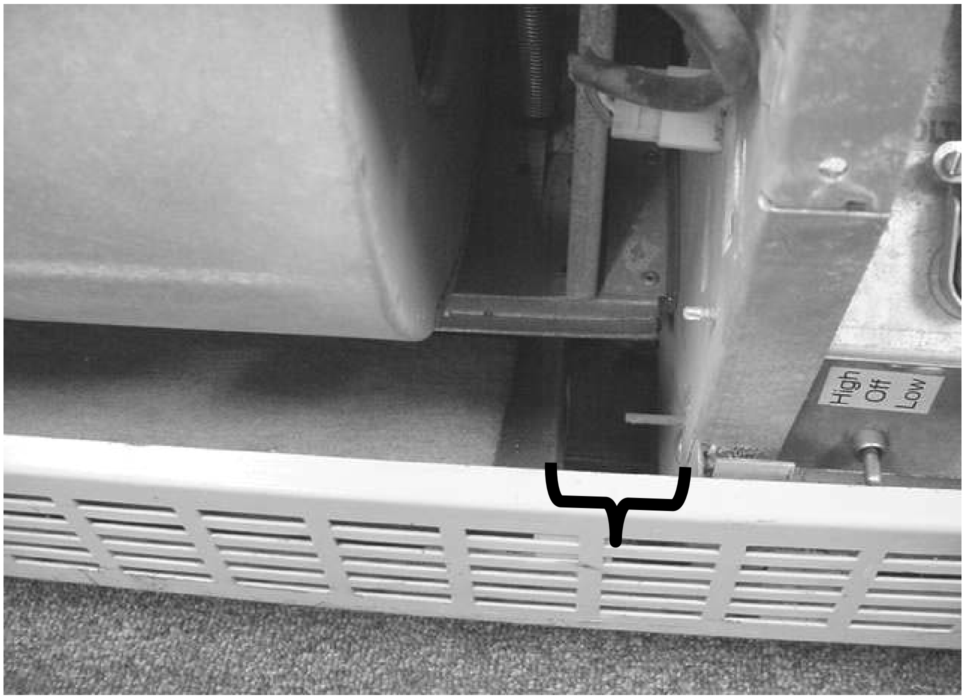
Picture 1

Exterior Wall Moistened During Rainstorm, Note Moisture Pattern at Base of Wall

Picture 2

Splashing Rainwater below Flooded Gutter

Picture 3



Short Filter Installed inside Univent, Note Space

Picture 4

Tennis Balls On Chair Legs

TABLE 1

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – April 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	417	60	40					10am
Main Office	703	72	41	6	no	yes	yes	
B26	623	74	41	5	yes	yes	yes	plants
A6	685	73	39	14	yes	yes	yes	window open,
A1	1026	75	45	15	yes	yes	yes	window open, upholstered furniture
A2	723	74	41	16	yes	yes	yes	window and door open
A3	873	74	40	13	yes	yes	yes	window open
A4	636	73	37	5	yes	yes	yes	chalk dust, window and door open
A5	660	74	38	18	yes	yes	yes	tennis balls, door open
A13	835	73	39	16	yes	yes	yes	door open
A16	675	72	38	17	yes	yes	yes	tennis balls, window open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – April 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
A9	845	71	40	11	yes	yes	yes	dry erase board
B41	571	72	38	2	yes	no	yes	window open
A15	929	72	40	19	yes	yes	yes	clutter, door open, accumulated food
A14	454	69	37	1	yes	yes	yes	window and door open, clutter
A18	659	73	40	17	yes	yes (2)	yes	1 out of 2 univents on, window open
A19	618	72	40	10	yes	yes	yes	
B42	616	72	38	17	yes	yes	yes	window and door open
B43	746	73	41	22	yes	yes	yes	window open
B37	926	72	40	17	yes	yes	yes	window open, water-damaged sink
B36	805	73	40	21	yes	yes	yes	
A11	681	70	39	5	yes	yes (2)	yes	1 out of 2 univents on, door open

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – April 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
B32	566	76	37	3	yes	yes	yes	
B35	1112	73	44	18	yes	yes	yes	throw pillows, door open
B34	782	75	39	12	yes	yes	yes	window and door open
B33	766	74	38	17	yes	yes	yes	window and door open
C12	664	73	37	7	yes	yes	yes	plants
C13	639	72	39	11	yes	yes	yes	univent off, window open
C14	721	73	38	7	yes	yes	yes	upholstered furniture, door open
C16	741	74	39	7	yes	yes	yes	upholstered furniture
C18	476	71	37	0	yes	yes	yes	door open
C20	462	73	35	0	yes	yes	yes	
C19	470	72	36	0	yes	yes	yes	

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – April 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Library	804	72	39	20+	yes	yes	yes	
Computer Room	2332	72	37	20	no	no	yes	21 computers, a/c
Music Room	771	73	39	1	no	yes	yes	occupants gone ~45 mins.
Art Room	1172	73	45	6	yes	yes	yes	tennis balls, busses outside, door open
Greenhouse	547	71	43	0		no	yes (4)	
Gym	1326	72	45	6	yes	yes	yes	

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Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Carbon Dioxide Air Monitoring Results Comparing November 2, 2000 and April 3, 2002
Undermountain Elementary School, Sheffield, MA

Location	Carbon Dioxide *ppm 11/2/2000	Occupants in Room 11/2/2000	Carbon Dioxide *ppm 4/3/2002	Occupants In Room 4/3/2002	Change after Repairs (+/-) *ppm	Comments
Outdoors	437		417			
Main Office	660	5	703	6	-43	
B26	679	11	623	5	-56	
A6	650	12	685	14	+35	Univent operating 4/3/2002
A1	774	0	1026	15	+252	
A2	980	12	723	16	-257	
A3	1019	1	873	13	-146	
A4	1137	13	636	5	-501	Univent operating 4/3/2002
A5	919	14	660	18	-259	

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 6

Carbon Dioxide Air Monitoring Results Comparing November 2, 2000 and April 3, 2002
Undermountain Elementary School, Sheffield, MA

Location	Carbon Dioxide *ppm 11/2/2000	Occupants in Room 11/2/2000	Carbon Dioxide *ppm 4/3/2002	Occupants In Room 4/3/2002	Change after Repairs (+/-) *ppm	Comments
A13	1028	16	835	16	-193	
A16	910	20	675	17	-235	
A15	982	21	929	19	-53	
A14	731	2	454	1	-277	
A18	492	3	659	17	167	
A19	689	8	618	10	-71	
B42	1401	0	616	17	-785	
B43	811	10	746	22	-65	
B37	895	10	926	17	31	

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X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 7

Carbon Dioxide Air Monitoring Results Comparing November 2, 2000 and April 3, 2002
Undermountain Elementary School, Sheffield, MA

Location	Carbon Dioxide *ppm 11/2/2000	Occupants in Room 11/2/2000	Carbon Dioxide *ppm 4/3/2002	Occupants In Room 4/3/2002	Change after Repairs (+/-) *ppm	Comments
B36	575	0	805	21	230	
B35	958	14	1112	18	154	
B34	850	0	782	12	-68	
B33	1080	16	766	17	-314	
C12	1777	18	664	7	-1113	
C13	801	21	639	11	-162	
C14	1292	16	721	7	-571	
C16	2017	17	741	7	-1276	
C18	1688	20	476	0	-1212	

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CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

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	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 8

Carbon Dioxide Air Monitoring Results Comparing November 2, 2000 and April 3, 2002
Undermountain Elementary School, Sheffield, MA

Location	Carbon Dioxide *ppm 11/2/2000	Occupants in Room 11/2/2000	Carbon Dioxide *ppm 4/3/2002	Occupants In Room 4/3/2002	Change after Repairs (+/-) *ppm	Comments
C20	1762	18	462	0	-1300	
C19	1104	17	470	0	-634	
Library	792	4	804	20+	12	
Computer Room	1334	18	2332	20	998	
Music Room	1040	1	771	1	-269	Univent operating 4/3/2002
Art Room	720	0	1172	6	452	
Greenhouse	533	0	547	0	14	
Gym	728	10+	1326	6	-598	
A11	-	-	681	5		

Comfort Guidelines

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CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 9

Carbon Dioxide Air Monitoring Results Comparing November 2, 2000 and April 3, 2002
Undermountain Elementary School, Sheffield, MA

*** ppm = parts per million parts of air**
CT = ceiling tiles
X = comparison carbon dioxide level not measured 2/7/2002

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Appendix I
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Actions on Previous Recommendations

As discussed, BEHA had previously made recommendations to improve indoor air quality (MDPH, 2001). The Southern Berkshire Regional School District and Undermountain Elementary School staff had implemented a number of these recommendations at the time of the reassessment and these efforts should serve to help improve indoor air quality in the building. The following is a status report of action(s) on BEHA recommendations based on reports from school officials, documents, photographs and BEHA staff observations.

1. **Remove materials blocking univents and exhaust vents.**

   Action Taken: Blockages from univents and exhaust vents were removed.

2. **Examine univents throughout the school for function. Survey classrooms for air diffuser and exhaust vent function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.**

   Action Taken: All univents (except room C13) were operating. Univents were repaired, as denoted by carbon dioxide measurements.

3. **Ensure that ground level fresh air intakes remain clear of blockages, particularly snow in winter. Avoid grass cutting during school hours.**

   Action Taken: Fresh air intake vents were free of obstructions.

4. **Examine the filters in the univents and AHU and change these filters on a regular basis. Consider increasing the dust spot efficiency of filters to increase the removal of particulates from the environment.**

   Action Taken: Filters in univents are changed on a regular basis.

5. **Once fresh air supply and exhaust systems are functioning, consider having the systems balanced by a ventilation engineer.**

   Action Taken: This activity continues as part of the overall maintenance of the ventilation system of the building complex.

6. **Examine each sink counter top for water damage. Seal the back splash/countertop seam with caulking to reduce water penetration. Examine the floor below the water-damaged wood for mold growth. If mold is present, disinfect any non-porous surfaces with an appropriate antimicrobial agent and subsequently clean with soap and water.**

   Action Taken: Water damaged sinks were repaired and seams sealed.

7. **Remove plants from univent air stream. Ensure plants have drip pans. Examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary.**

   Action Taken: A number of plants continue to exist in classrooms.

8. **Move animal cages away from univents. Clean cage materials from tables and disinfect tables with an appropriate antimicrobial agent daily. Clean nesting materials from the interior of cages frequently.**

   Action Taken: All animals were removed from classrooms.

Appendix I
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9. **Store cleaning products and chemicals properly and keep out of reach of students..**

Action Taken: No cleaning products were found stored in the open in classrooms.